

## 4.3.7 Lightning Strike

This section provides a profile and vulnerability assessment for the lightning strike hazard. Lightning is a rapid discharge of electrical energy in the atmosphere. When the charge difference between the ground and the cloud becomes too large, a conductive channel of air develops between the cloud and the ground, and a small amount of charge (step leader) starts moving toward the ground. When it nears the ground, an upward leader of opposite charge connects with the step leader. At the instant this connection is made, a powerful discharge occurs between the cloud and the ground and the discharge is seen as a bright flash of lightning.

### 4.3.7.1 Location and Extent

More than 100,000 thunderstorms occur in the United States (U.S.) each year, with lightning striking more than 25 million points on the ground during that same period causing numerous injuries and fatalities (NOAA, Date Unknown). Lightning can occur with all thunderstorms, making all of the Lehigh Valley susceptible. Different geographic areas experience varying event frequencies, but in all cases lightning strikes and associated fatalities occur primarily during the summer months.

While the impact of lightning events is highly localized, strong storms can result in numerous widespread events over a broad area. According to the Commonwealth of Pennsylvania 2010 Standard All-Hazard Mitigation Plan (PA HMP), Northampton County has one of the highest lightning risks of all counties in Pennsylvania. Lehigh County is not listed among one of the top five most at-risk counties.

### 4.3.7.2 Range of Magnitude

Because lightning damage is largely unreported, statistics vary considerably. The insurance industry, however, estimates that 6.5 percent of all property/casualty claims are related to lightning strikes. While it is difficult to quantify lightning losses, it is estimated that \$4 to \$5 billion in damage occurs each year across the U.S. Likewise, the cost of lightning protection to safeguard critical equipment and facilities from lightning strikes during severe weather is enormous (BCPC, 2011).

Each year, lightning strikes across the U.S. are responsible for an average of between 55 and 60 fatalities, several hundred injuries, and billions of dollars in property damage. Many case histories show observed heart damage, inflated lungs, and brain damage in lightning fatalities. Loss of consciousness, amnesia, paralysis and burns are reported by many who have survived. Deaths and injuries to livestock and other animals, thousands of forest and brush fires, as well as damage to buildings, communications systems, power lines, and electrical systems are also the result of lightning (PEMA, 2010).

Between 2000 and 2010, Pennsylvania ranked 10<sup>th</sup> among all states in the U.S. with 13 deaths, representing approximately three percent of all lightning-caused deaths in the U.S. over that period of time (NOAA, NWS, 2012). Between 1959 and 1994, Pennsylvania ranked third among all states in the U.S. with 644 casualties (i.e. combination of deaths and injuries). This represents approximately five percent of casualties which occurred throughout the U.S over that 35-year period (PEMA, 2010).

The Lehigh Valley's worst lightning event in terms of property damage occurred on August 25, 2007, when lightning struck a church in Plainfield Township, resulting in a fire and an estimated \$250,000 in damage. Shortly after the church was struck, lightning struck and destroyed a saw mill in Upper Mount Bethel Township, which resulted in an additional \$1 million dollars in loss. No injuries were reported.

With regards to loss of life and injuries, the Lehigh Valley’s worst lightning event occurred in Northampton County on July 19, 2011, when a father and daughter were struck by lightning as they stood under a tree at the Moore Township Recreation Fields. The father was holding an umbrella over his daughter's head when they were both thrown to the ground by the lightning bolt. The father had burns on his feet, stomach and leg and felt numbness and a burning sensation. The daughter suffered a flash burn to her right eye (NCDC, 2012).

#### 4.3.7.3 Past Occurrence

A lightning “event” is defined as a lightning strike which results in fatality, injury, and/or property or crop damage (PEMA, 2010). Records from the National Climatic Data Center (NCDC) and the Pennsylvania Emergency Incident Reporting System (PEIRS) show that there were 74 reported lightning events in the Lehigh Valley between 1993 and 2011 (refer to Table 4.3.7-1 below). Between 1993 and 2011, Northampton County recorded 46 lightning events, averaging 2.5 events every year. Lehigh County only experienced 28 recorded events over the same time period. Sixty of the 62 municipalities in the Lehigh Valley reported five or fewer events over this 18 year period. Of the Lehigh Valley municipalities with the highest numbers of lightning events, the City of Easton reported eight events, the City of Allentown reported seven events, and the City of Bethlehem reported six events.

*Table 4.3.7-1. Lehigh Valley Recorded Lightning Events*

County	Location	Date	Death	Injuries	Property Damage (\$)
<b>Lehigh County</b>					
Lehigh	City of Allentown	9/15/1993	0	0	50,000
Lehigh	City of Allentown	6/6/1994	0	0	-
Lehigh	City of Allentown	7/17/1995	0	2	-
Lehigh	City of Allentown	5/13/2000	0	0	50,000
Lehigh	Whitehall Township	7/1/2001	0	0	5,000
Lehigh	Lower Milford Township	5/13/2002	0	0	-
Lehigh	Upper Saucon Township	8/2/2002	0	0	-
Lehigh	Macungie Borough	7/22/2003	0	0	81,000
Lehigh	Salisbury Township	8/3/2003	0	1	-
Lehigh	City of Allentown	8/3/2003	0	0	-
Lehigh	City of Allentown	6/6/2005	0	0	-
Lehigh	Whitehall Township	6/6/2005	0	0	250,000
Lehigh	Upper Milford Township	7/1/2005	0	0	-
Lehigh	North Whitehall Township	8/8/2005	0	0	10,000
Lehigh	Macungie Borough	6/19/2006	0	0	-
Lehigh	South Whitehall Township	7/5/2007	0	0	1,000
Lehigh	Whitehall Township	7/29/2007	0	0	1,000,000
Lehigh	Macungie Borough	6/10/2008	0	0	10,000
Lehigh	Upper Saucon Township	8/8/2008	0	0	10,000
Lehigh	North Whitehall Township	8/13/2008	0	0	50,000
Lehigh	South Whitehall Township	4/11/2011	0	0	1,000
Lehigh	City of Allentown	7/24/2011	0	0	25,000

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County	Location	Date	Death	Injuries	Property Damage (\$)
<b>Northampton County</b>					
Northampton	Upper Mount Bethel Township	7/8/1994	0	0	-
Northampton	Lehigh Township	7/11/1995	0	0	-
Northampton	City of Bethlehem	7/11/1995	0	0	200,000
Northampton	Nazareth Borough	7/17/1995	0	0	-
Northampton	Nazareth Borough	7/17/1995	0	0	-
Northampton	Hellertown Borough	8/5/1995	0	0	40,000
Northampton	City of Bethlehem	3/19/1996	0	0	-
Northampton	Tatamy Borough	6/17/1996	0	0	-
Northampton	Moore Township	7/3/1996	0	0	40,000
Northampton	Belfast, Plainfield Township	7/8/1996	0	1	-
Northampton	Wilson Borough	5/6/1997	0	0	20,000
Northampton	Bath Borough	8/16/1997	0	0	100,000
Northampton	City of Easton	5/6/1998	0	0	-
Northampton	Pen Argyl Borough	5/25/1998	0	0	-
Northampton	Wind Gap Borough	5/29/1998	0	0	-
Northampton	Lehigh Township	5/10/2000	0	1	-
Northampton	Nazareth Borough	5/13/2000	0	1	-
Northampton	City of Easton	5/13/2000	0	1	-
Northampton	Nazareth Borough	5/18/2000	0	0	-
Northampton	City of Easton	5/24/2000	0	0	-
Northampton	City of Easton	6/11/2000	0	1	-
Northampton	City of Bethlehem	12/17/2000	0	0	10,000
Northampton	Wilson Borough	4/9/2001	0	0	-
Northampton	City of Bethlehem	7/1/2001	0	0	1,000
Northampton	Forks Township, Washington Township	7/10/2001	0	0	10,000
Northampton	Forks Township, Washington Township	7/10/2001	0	0	50,000
Northampton	City of Bethlehem	8/12/2001	0	1	-
Northampton	City of Easton	6/27/2002	0	0	-
Northampton	Forks Township	8/3/2003	0	0	250,000
Northampton	Countywide	5/12/2004	0	0	-
Northampton	Bethlehem Township	5/15/2004	0	1	-
Northampton	Bethlehem Township	6/17/2004	0	0	-
Northampton	Lower Mount Bethel Township	3/28/2005	0	0	140,000
Northampton	Newburg, Lower Nazareth Township	6/6/2005	0	0	-
Northampton	City of Easton	6/6/2005	0	0	-
Northampton	City of Easton	7/10/2005	0	0	-
Northampton	Bath Borough	1/14/2006	0	0	50,000

County	Location	Date	Death	Injuries	Property Damage (\$)
Northampton	Glendon Borough	6/19/2006	0	0	-
Northampton	City of Bethlehem	6/21/2006	0	0	5,000
Northampton	City of Easton	6/27/2007	0	0	10,000
Northampton	Bethlehem Township	7/10/2007	0	0	100,000
Northampton	Moore Township	8/8/2007	0	0	55,000
Northampton	Belfast, Plainfield Township	8/25/2007	0	0	1,300,000
Northampton	Moore Township	5/23/2009	0	0	350,000
Northampton	Bethlehem Township	8/5/2009	1	0	-
Northampton	Moore Township	7/19/2011	0	2	-
<b>Lehigh Valley Total</b>			<b>1</b>	<b>12</b>	<b>\$4,274,000</b>

Source: NCDC, 2012; PEIRS, 2012

#### 4.3.7.4 Future Occurrence

Lightning strikes that result in multiple fatalities have never been reported in the Lehigh Valley. Those that resulted in multiple injuries and/or extensive property damage have occurred 35 times over 18 years of record (1993 to 2011). The future occurrence of lightning activity in the Lehigh Valley is anticipated, and the susceptibility to damage from these events will remain unchanged. The future occurrence of lightning strikes can be considered *likely* as defined by the Risk Factor Methodology probability criteria (refer to Section 4.4).

#### 4.3.7.5 Vulnerability Assessment

To understand risk, a community must evaluate what assets are exposed or vulnerable in the identified hazard area. For lightning events, the entire Lehigh Valley has been identified as the hazard area. Therefore, all assets (population, structures, critical facilities and lifelines), as described in Section 2, are vulnerable. The following text evaluates and estimates the potential impact of lightning strike events on the Lehigh Valley including:

- Overview of vulnerability
- Data and methodology used for the evaluation
- Impact on: (1) life, safety and health of residents, (2) general building stock, (3) critical facilities, (4) economy and (5) future growth and development
- Effect of climate change on vulnerability
- Further data collections that will assist understanding this hazard over time

##### 4.3.7.5.1 Overview of Vulnerability

Evaluation of NCDC and PEIRS lightning data for the Lehigh Valley, along with data from the current and previous versions of the PA HMP, show that while the absolute number of lightning events has changed for individual municipalities, the basic pattern of vulnerability across the Lehigh Valley has remained relatively consistent.

The potential for lightning strikes will continue to exist for all 62 municipalities in the Lehigh Valley. The direct and indirect losses associated with these events include injury and loss of life, damage to

structures and infrastructure, agricultural losses, utility failure (power outages), and stress on community resources.

Lehigh County is a StormReady county. This designation is obtained through participation in the National Weather Service (NWS) StormReady Program, which includes six guidelines met by the County:

- **Communication** – A 24-hour warning point (WP) must be fully staffed at all times, and a County Emergency Operations Center (EOC) must be established.
- **NWS Information Reception** – At least four redundant systems must be in place at the WP to receive weather warnings.
- **Hydrometeorological Monitoring** – At least four methods of monitoring hydrometeorological data must be available.
- **Local Warning Dissemination** – There must be at least four redundant systems to notify the County of severe weather warnings, and there must be National Weather Radio-Specific Area Messaging Encoding receivers in public facilities.
- **Community Preparedness** – The County must present at least four annual weather safety talks, spotters and dispatchers must be trained biennially, and the County must host or co-host NWS spotter training annually.
- **Administration** – The County must also meet a number of administrative criteria that include formal hazardous weather operations planning, biennial visits of the County Emergency Management Coordinator (EMC) to the NWS office, and annual visits by an NWS official to the County.

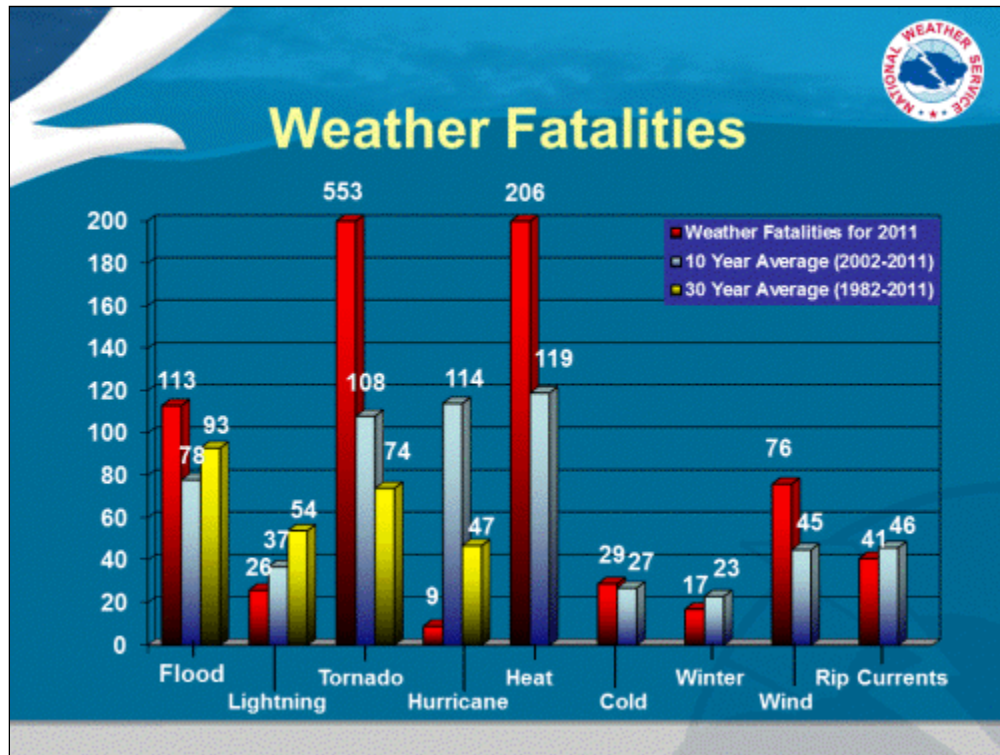
Meeting the criteria of the StormReady program results in a decrease in vulnerability to all severe weather events, including lightning strikes.

#### 4.3.7.5.2 Data and Methodology

National weather databases and local resources were used to collect and analyze lightning impacts on the Lehigh Valley.

#### 4.3.7.5.3 Impact on Life, Health and Safety

Across the U.S., the ten year average (2001 to 2011) for fatalities caused by lightning is 37 while the 30-year average (1982 to 2011) is 54 (NOAA, 2012). Refer to Figure 4.3.7-1 for an illustration of these statistics. According to NOAA, there has been one fatality and 12 injuries as a result of lightning events from 1993 and 2011 in the Lehigh Valley (NCDC, 2012; PEIRS, 2012).

*Figure 4.3.7-1. Weather Fatalities in the U. S.*

Source: NOAA, 2012

The entire population of the Lehigh Valley is considered exposed to the lightning hazard. Lightning strikes in Pennsylvania occur primarily during the summer months. In general, population and building density have a correlation with hazard vulnerability and loss. The urban areas of the Lehigh Valley are at greater lightning risk than others due to higher population density. Populations located outdoors are considered at risk and more vulnerable to a lightning strike compared to being inside a shelter. Moving to a lower risk location will decrease a person's vulnerability.

#### 4.3.7.5.4 Impact on General Building Stock, Critical Facilities and the Economy

For the purposes of this Plan, the entire general building stock and all infrastructure of the Lehigh Valley are considered exposed to the lightning strike hazard. In general, urban and suburban areas in the Lehigh Valley are at greater lightning risk than more rural areas others due to higher population and structure density. Taller buildings can act as lightning rods; therefore, they naturally have experienced greater vulnerability and loss during past lightning strike events (PEMA, 2010).

The precise vulnerability of lightning strikes will depend on a facility's height vis-à-vis surrounding buildings as well as the absence or presence of a lightning rod or other lightning channeling technology in the structure. According to the PA HMP, fire departments, schools, and police departments are the most vulnerable to lightning strikes. Food and agriculture facilities that raise livestock may also be more vulnerable to lightning strikes as these animals tend to shelter under trees in storm situations. It is important to note that most of the food and agriculture-related critical facilities are privately owned farms that may own sizeable herds of livestock, but the Commonwealth critical facilities list does not indicate which of the farms own herds. Finally, if the entertainment and recreation facilities are outdoor recreation spaces with wide open spaces, there may be added lightning strike vulnerability (PEMA, 2010).



According to NOAA’s Technical Paper on *Lightning Fatalities, Injuries, and Damage Reports in the United States from 1959 - 1994*, monetary losses for lightning events range from less than \$50 to greater than \$5 Million (larger losses associated with forest fires with homes destroyed and crop loss) (NOAA, 1997). Lightning can be responsible for damages to buildings; cause electrical, forest and/or wildfires; and damage infrastructure such as power transmission lines and communication towers. Agricultural losses can be devastating due to lightning and resulting fires.

The PA HMP identified Northampton County as one of five counties throughout the state as highly vulnerable to lightning strike hazards. The County hosts 246 state critical facilities of the total 1,521 state critical facilities spread among the five vulnerable counties (PEMA, 2010).

The State HMP estimated jurisdictional losses for the five counties most threatened by lightning strike, including Northampton County. Using GIS, losses for the County were estimated to total over \$36 Million. No estimates were prepared for Lehigh County, as it was not evaluated as a highly vulnerable county to the lightning strike hazard. Note that losses due to lightning strikes will differ based on the magnitude of the event and the lightning protection measures on a given facility (PEMA, 2010).

#### 4.3.7.5.5 Future Growth and Development

Areas targeted for potential future growth and development in the next five (5) years have been identified across the Lehigh Valley at the municipal level. Refer to the jurisdictional annexes in Volume II of this Plan. Table B.1 in each jurisdictional annex lists the location of the potential new development and its exposure (if any) to known hazard zones. It is anticipated that new development will be exposed to the lightning strike hazard.

#### 4.3.7.5.6 Effect of Climate Change on Vulnerability

Climate is defined not simply as average temperature and precipitation but also by the type, frequency and intensity of weather events. Both globally and at the local scale, climate change has the potential to alter the prevalence and severity of extremes such as storms, including those which may bring lightning. While predicting changes of lightning events under a changing climate is difficult, understanding vulnerabilities to potential changes is a critical part of estimating future climate change impacts on human health, society and the environment (U.S. Environmental Protection Agency [EPA], 2006).

Since the 1970s, globally there has been an increase in ‘tropical cyclone destructiveness’ as measured by the Power Dissipation Index. This increased tropical cyclone intensity and duration correlates with sea surface temperature. This suggests that future increases of tropical sea surface temperature may lead to future increases in tropical cyclone intensity and duration. However, there is a high level of uncertainty regarding the relationship between climate change and storm events. Future improvements in modeling smaller scale climatic processes can be expected and will lead to improved understanding of how the changing climate will alter temperature, precipitation and storms events in Pennsylvania (Shortle et. al, 2009).

#### 4.3.7.5.7 Additional Data and Next Steps

The assessment above identifies vulnerable populations and potential structural and economic losses associated with the lightning strike hazard. Research at NOAA and other private organizations is ongoing to improve warning and threat information for the public. The continued collection of additional/actual loss data specific to the Plan participants will further enhance the Lehigh Valley’s vulnerability assessment.